A Strategy for the Integration of Professional Practice within Ph.D. Study

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Introduction

As designers make the career transition from practitioner to educator, it is all too easy to loose the core competencies of professional practice as the contrasting role of the academic takes over. This can be compounded by a requirement of institutions to focus nonteaching activity on research and, possibly, attaining a Ph.D. However, this progression may not necessarily be in the best interests of students, where emerging skills and knowledge are most effectively developed through the direct demonstration of technique, critique, and modification of designs through drawing and provision of practice-based case study material that has been undertaken by the tutor.

This paper explores the nature of master's and Ph.D. study in design and identifies the development of a methodology for a Ph.D. that enabled the researcher to be actively involved in the industrial design of four consumer products. The key outcomes of this strategy were that professional skills and knowledge were maintained and extensive material made available for undergraduate and masters teaching. These outcomes were not regarded as a consequence of the research activity, but very much at its core, being orchestrated through a perceived need to maintain professional skills and knowledge and make a full contribution to the quality and relevance of student learning.

Master's Study

If one accepts the purpose of undertaking a nonresearch master's degree as being "to acquire higher levels of knowledge, skills, and sensibility in a discipline" (Archer, 2004), its timing as a precursor to entering professional practice as a designer makes perfect sense. Reflecting on the design education undertaken by the author, gaps were felt to exist in the skills and knowledge afforded by undergraduate design education and a two year masters programme proved effective in addressing these shortcomings. In particular, as part of the master's program, client-based projects enabled a relatively naive designer to operate at a senior level within sponsoring companies. However, the format of study was largely based on lectures and an engagement in specific, well-defined design exercises using established design methods. The application of "typical" design techniques led to "typical" product outcomes such as an optical disc video camera.

The skills, knowledge, and contacts gained on the masters course resulted in a job being offered (and accepted) with a consumer product manufacturer. This was followed with a position in a consultancy before entering academia as a lecturer in industrial design.

Doctoral Study

On entering academia after gaining considerable experience of commercial industrial design practice, it became clear that opportunities existed to employ this expertise as part of a Ph.D. In fact, an added appeal was the fact that this would be pioneering work as there were very few Ph.D.s in existence where the researcher had directly engaged in industrial design activity as a core component of the study. The Ph.D. therefore had the potential to demonstrate a strategy for the integration of professional practice and, by association, the extent to which a Ph.D. might take over from master's study as the terminal degree for vocational learning. This contrasts with McCarron's comment that "because doctoral programs are research-based, many professionals question the relevancy of such a degree to professional practice. They are concerned that the profession's participation in heady academic discourse will remove design from the real world" (McCarron , 2000).

Archer (2004) has identified the three key purposes of a Ph.D. as being:

- To demonstrate competence in higher levels of research skills
- To make a substantial contribution to knowledge in a given discipline
- To become qualified to supervise others in the conduct of research programs

He goes on to define the distinguishing features of a Ph.D. program as being

- the critical appraisal by the candidate of prior research
- close attention to the principles and practice of research methodology
- the conduct of a single major systematic investigation
- the delivery of a substantial contribution to knowledge

With relatively few preconditions to Ph.D. study, significant opportunities exist for the academic wishing to employ their design skills and knowledge as part of the research activity. It is just a case of how?

With a master's qualification and experience as both an in-house and consultant industrial designer, skills and knowledge associated with professional practice were relatively well developed, with a broad perspective on the capabilities and limitations of the various design methods/tools. Design technologies were of particular interest, including computer-aided design (CAD), computer-aided industrial design (CAID), and rapid prototyping (RP).

Having undertaken an initial literature review, the aim of the Ph.D. evolved to focus on a methodological approach for the effective integration of rapid prototyping within industrial design practice (Evans, 2002). It was felt that opportunities for research in this area would lead to the key requirements of a Ph.D., i.e., involve the critical appraisal of prior research; pay close attention to the principles and practice of research methodology; be a single major systematic investigation; and enable the delivery of a substantial contribution to knowledge (Archer, 2004).

As a former practitioner, it was the requirement to pay close attention to the principles and practice of research methodology that posed the greatest challenge: having to convert from working practices that involved controlled creativity with a degree of subjectivity to one that required rigour and sound academic method. This was further compounded by the desire to integrate professional practice undertaken by the researcher as a major component of the study. In many respects, by including a significant amount of professional practice, the content of the Ph.D. evolved to have a close association with master's study, albeit with the addition of a research agenda and associated methods.

Research Methods

The focus of the study was in the field of professional practice, with an objective to evaluate and facilitate the integration of a specific technology (rapid prototyping). As such, the use of case-study methods was considered a relevant and reliable research tool. Case studies have been described as an approach to research as opposed to a research method (Moore, 1983) with a capability "to describe and understand the phenomenon 'in depth' and 'in the round' [completeness]. In this role, case studies serve a useful purpose, since many important issues can be overlooked in a more superficial survey" (Birley and Moreland, 1998). In addition, the way in which data are collected and analyzed "implies the collection of unstructured data, and qualitative analysis of those data" (Gomm and Hammersley, 2000). The principle of an in-depth investigation into the integration of rapid prototyping within industrial design practice through the use of case study methods formed the core of the doctoral study.

In focusing on specific methods applied as part of case study research, Moore (1983), Gomm and Hammersley (2000*)* and Cohen and Manion (1980) identify action research. Action research has been defined as "an on-the-spot procedure designed to deal with a concrete problem located in an immediate situation. This means that the step-by-step process is constantly monitored (ideally, that is) over varying periods of time and by a variety of mechanisms (questionnaires, diaries, interviews and case studies, for example) so that the ensuing feedback may be translated into modifications, adjustments, directional changes, redefinitions, as necessary, so as to bring about lasting benefit to the ongoing process itself." (Cohen and Manion, 1980)

The cyclical nature of action research has been identified by Birley, who sees it as being conducted by a professional into their own activity, the aim of which is to bring about an improvement in practice (Birley, 1998). Action research was therefore considered particularly appropriate in meeting the objectives of the Ph.D., as it represented a recognized research approach for the facilitation of improvements in the execution and understanding of practice (Garner, 1999).

In employing action research through a series of case studies, a strategy of reflective designing was adopted whereby the researcher undertook the role of industrial designer and articulated the process and outcome. The process of reflective designing is described by Schon when he states "The designer's moves tend, happily or unhappily, to produce consequences other than those intended. When this happens, the designer may take account of the unintended changes he has made in the situation by forming new appreciations and understandings and by making new moves. He shapes the situation, in accordance with his initial appreciation of it, the situation 'talks back', and he responds to the situation's back-talk." (Schon, 1983)

The use of action research through a series of case studies formed a primary research element for the Ph.D. and whilst this resulted in design outcomes, the focus remained on the process and not the specific product outcomes.

The principal research methods used during the study were literature review, case study, and action research. Survey methods were also employed to support the major case study, and a weighting/rating method used to appraise the methodological approach. These methods were integrated into a five-phase research strategy involving: literature review, definition and application of the draft computer-aided industrial design/rapid prototyping (CAID/RP) methodological approach, revision of this approach, comparative evaluation of physical models, resolution of modelling issues, use of an appraisal framework, and definition of the final CAID/RP methodological approach. A diagrammatic representation of the five-phase research methodology can be seen in Figure 1.

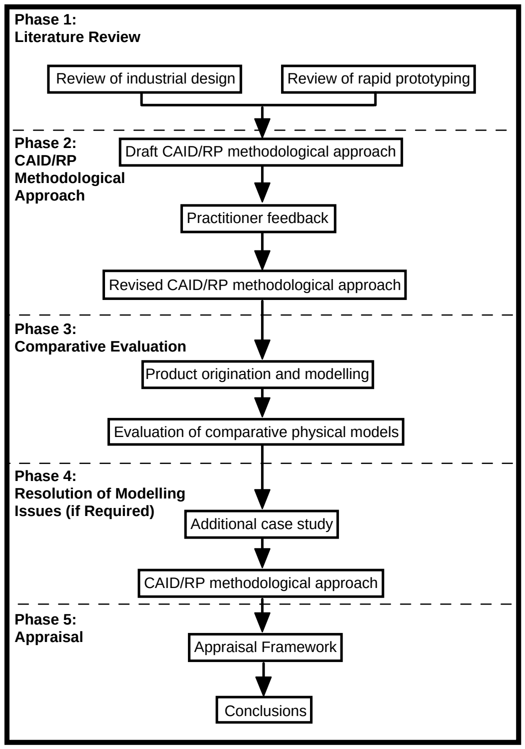

Figure 1: Five-phase research methodology

Five-Phase Research Methodology

The literature review of phase 1 explored the nature of industrial design and capabilities of rapid prototyping. This provided parameters for the study by giving a working definition of industrial design, identifying the activities involved in professional practice, and contributing an overview of rapid prototyping.

Phase 2 defined a 'Draft CAID/RP methodological approach' that integrated computer-aided industrial design techniques with those of rapid prototyping. A diagrammatic representation of the Draft CAID/RP methodological approach can be seen in Figure 2.

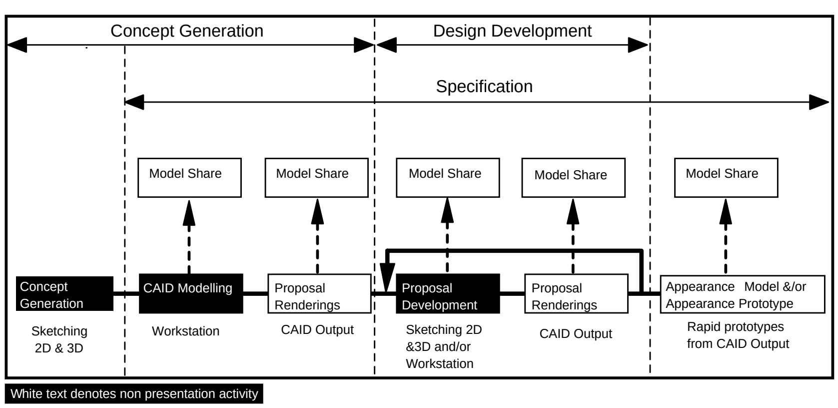

Figure 2. Draft CAID/RP methodological approach

As a precursor to a major case study, the draft CAID/RP methodological approach was exposed to practitioner feedback and information sought on the extent to which industrial designers employed rapid prototyping. Survey methods are an accepted form of data collection (Birley and Moreland, 1998)(Moore, 1983) and was employed through a postal questionnaire sent to every industrial design consultancy in the UK that was a member of the Chartered Society of Designers. Having analyzed the results of the survey, a requirement to have a feedback loop on the appearance model/prototype was identified and integrated into a revised CAID/RP methodological approach.

Phase 3 evaluated the Revised CAID/RP methodological approach via a major case study. This phase generated an innovative design for an electric garden trimmer, applied the modelling methods of the CAID/RP methodological approach, and concluded with the assembly of an appearance model and appearance prototype produced using rapid prototyping. In addition to this model and prototype, an additional appearance model was produced using conventional workshop-based fabrication techniques. In the context of the research, the two appearance models and appearance prototype enabled a comparative evaluation to be made between the outcomes from rapid prototyping and conventional workshop-based fabrication techniques by documenting costs and build times. Details of the appearance model produced using rapid prototyping (left) and detail of the appearance model produced using workshop-based fabrication techniques (right) can be seen in Figure 3.

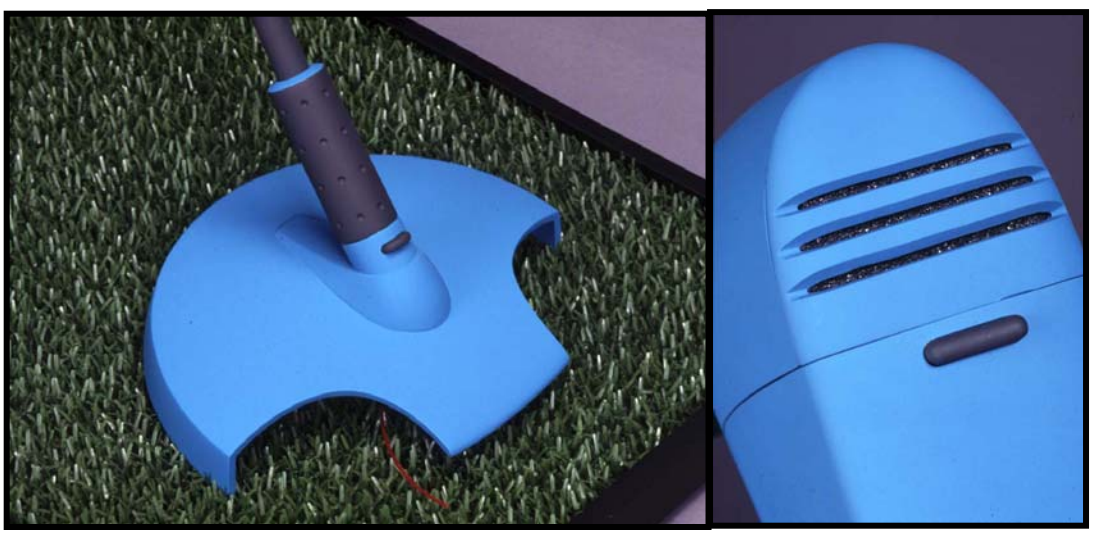

Figure 3. Detail of cutter guard on appearance model produced using rapid prototyping and detail of air intake on appearance model produced using workshop-based fabrication techniques.

Phase 4 provided an opportunity to reflect on and modify the revised CAID/RP methodological approach through an additional case study by employing the cyclical nature of action research as identified by Cohen and Manion (1980) and Birley (1998). However, not one but three additional case studies were required to resolve issues identified during phase 3. The three issues identified via the application of the revised CAID/RP methodological approach were that:

1. Considerable rigor was needed to produce the 3D CAD geometry required for rapid prototyping

2. Rapid prototyping could not make a cost-effective contribution to the production of physical sketch models

3. As a remote build system, rapid prototyping removed the ability for the designer to engage in the definition of form through the tactile sculpting of material.

These issues were the subject of further literature review and potential solutions identified and integrated into an amended research methodology that added three instead of the previously specified one additional case study. These three issues went on to be investigated and resolved to varying degrees of success.

Issue 1 was addressed by using a surface-based 3D computer- modelling package more closely associated to the needs of industrial designers in the definition of exterior form. The geometry was then exported into a CAD system for the addition of details required for rapid prototyping (i.e., wall thickness). This issue was explored during a case study involving the design of an automotive control binnacle (see Figure 4).

Figure 4. CAID rendering of industrial design proposal as surface geometry only.

Issue 2 was addressed by using a low-cost concept modelling rapid prototyping system (Z-Corp) to explore alternatives of form in a similar way to the established practice of sculpting Styrofoam. However, the rapid prototyping system did not allow any direct sculpting by hand because the components were translated from CAID geometry by the rapid prototyping system. This method was used to produce a range of size variants during the design of children's cutlery (Figure 5).

Figure 5. Concept models produced via rapid prototyping (Z-Corp) used to explore product size.

Issue 3 was addressed by using a haptic feedback device to provide tactile feedback from a virtual model. As rapid prototyping systems do not allow the designer to interact with form during the build process, this capability was re-introduced using a haptic feedback device. This enabled the designer to have a degree of tactile interaction with the 3D computer model during the design of a range of jewelry-based communication devices. The computer rendering of the textured surface that was produced by 'touching' the virtual geometry can be seen in Figure 6. The geometry was then used to produce the physical components via rapid prototyping.

Figure 6. Rendering of communication device modelled using a haptic feedback device.

Having resolved the three modelling issues with varying degrees of success, the outcomes enabled the final CAID/RP methodological approach could be defined.

The key feature of the CAID/RP methodological approach was the capacity to operate almost exclusively in a digital environment whilst still engaging in a degree of tactile interaction with the emerging form. This strategy facilitated the use of rapid prototyping in the production of the three forms of physical model as required during industrial design practice i.e., sketch model, appearance model, appearance prototype.

The final phase of the Ph.D. was to validate the CAID/RP methodological approach using an appraisal framework. This involved a series of interviews with industrial design practitioners from a range of professional positions e.g., consultant, in-house, small manufacturer, multinational.

The interviewees received a briefing on the methodological approach followed by the completion of a questionnaire that was later normalized using a weighting /rating method (Pugh, 1991). The outcomes from the appraisal framework gave a percentage score for the success (or otherwise) of the CAID/RP methodological approach. The average score for the weighting/rating method was a perceived improvement in working practice of 21.5% when compared with current techniques.

Conclusion

The conflicting demands of a research-driven academic career (certainly in the UK) can make it difficult to maintain the professional skills and knowledge that are considered essential for effective undergraduate and taught master's teaching and learning. However, the development of a practice-based Ph.D. proved to be a vehicle whereby this could be redressed to not only maintain professional design capability, but its extension and enhancement through the use of new and emerging technologies. In fact, it is considered highly unlikely that many of the technologies would have been employed if the designer was practicing in a commercial environment.

It typically takes around three years of full-time and a minimum of five years part-time study to complete a Ph.D. in the UK. It is therefore necessary to be mindful of the dynamic nature of technological progress and the requirement for a Ph.D. to be timely. This study identified the fact that when undertaking study over an extended period, a technology that was once considered emerging can all too soon become routine e.g., rapid prototyping. When undertaking technology-driven practice-based research over several years, it is therefore necessary to be aware of the dynamic nature of progress in the field and seek further opportunities accordingly. For the Ph.D. discussed in this paper, it was possible to move the study forward into rapid prototyping by the inclusion of CAID, concept model rapid prototyping and haptic feedback modelling.

This research has challenged the assumption that the Ph.D. is not necessarily an appropriate qualification for those wishing to enter professional design practice. More significantly, it demonstrates a strategy for the maintenance of professional industrial design skills and knowledge by lecturers wishing to progress their academic career through Ph.D. study. The key challenge for those wishing to undertake this approach is the identification of research questions that can be addressed through case study methods that employ and extend their professional design capability.

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